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Heterosis on Body Weights in Crosses Among Brahman, Santa Gertrudis and Cheju Native Cattle

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HETEROSIS ON BODY WEIGHTS IN CROSSES AMONG BRAHMAN, SANTA GERTRUDIS AND CHEJU NATIVE CATTLE

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SUMMARY

Data obtained from 428 calves (59 Cheju native cattle, 60 Brahman, 40 Santa Gertrudis and 269 crossbreds) were analyzed to estimate main effects of environmental factors and heterosis. Mating type, sex of calf, and year of birth were significant sources of variation on most of the weights at preweaning and post weaning periods. Brahman x Cheju native cattle cross showed heterosis of 6.1% on birth weight. Maternal heterosis on weaning weight was 4.9% in Brahman backcrosses and 12.3% in Santa Gertrudis backcrosses.

INTRODUCTION

Systematic crossbreeding provides for use of heterosis and of differences among breeds to optimize average genetic merit of traits for adaptability to the various climatic and nutritive environments encountered in beef production (Dickerson, 1973; Gregory and Cundiff, 1980; Koch et al., 1985). The factor that could be responsible for continued improvement when grading is practiced is the introduction of desirable additive genes with plus effects into a herd that originally lacked them (Lasley, 1978). When using the crossbred cow, maternal advantages associated with backcross have been implied (McDonald and Turner, 1972).

The objectives of this study were to estimate additive, non-additive and maternal heterotic effects in crossbreds from an experiment designed to improve economically important traits of Cheju native cattle and adaptability to poor quality pastures in a subtropical climatic conditions.

MATERIALS AND METHODS

The animals used in this study were produced at the Cheju Experiment Station, Korea from 1974 through 1980. The experiment was initiated in 1958 to improve traits of small sized Cheju native cattle (Bos taurus) by grading up with exotic Brahman and Santa Gertrudis (first phase) and then to compose new lines of beef cattle (second phase). The composite lines purposed were one with 5/8 Brahman + 3/8 Cheju native cattle and the other with 5/8 Santa Gertrudis + 3/8 Cheju native cattle.

The animals were maintained within barns and fed hays and some supplement during winter period. They were out to the pastures with a little improved forages from April 15 through October 31. The records on the total of 428 calves (159 straightbreds and 269 crossbreds) were used in this study. The data on the weights at birth, 6, 12 and 18 months of age were analyzed according to the model including fixed main effects of mating type, sex of calf, parity, age of dam and year of birth. Preliminary analyses showed no significant interaction among any of the factor combinations.

The following mathematical model for the phenotypic value of a crossbred calf was used to estimate additive, non-additive and maternal heterotic effects in backcrosses.

$$P_{iij} = A_{iij} + S_{iij} + M_{ij}$$

$$= (\tfrac{1}{2}B_i + \tfrac{1}{4}B_i + \tfrac{1}{4}B_j) + \tfrac{1}{2}((B_i - \tfrac{1}{2}(B_i + B_i)) + (B_{ij} - \tfrac{1}{2}(B_i + B_j)))$$

$$+ (B_{iij} - \tfrac{1}{2}(B_i + B_{ij}))$$

$$= \tfrac{1}{4}(3B_i + B_j) + (\tfrac{1}{2}B_{ij} - \tfrac{1}{4}B_i - \tfrac{1}{4}B_j) + (B_{iij} - \tfrac{1}{2}(B_i + B_{ij}))$$

where

P_{iij} = average phenotypic value of backcross calves by i th sires and single-cross dams of i th and j th breeds

A_{iij} = additive contribution of i th and j th breeds

S_{iij} = non-additive effects of the calf which by definition of heterosis is the difference between the average performance of a cross between two groups and the average performance of the two parent groups

M_{ij} = maternal heterosis exhibited by the singlecross dam defined as the average performance of the singlecross progeny from the parental breeds of the dam

B_i, B_{ij}, B_{iij} = values attributable to the calves of the specific genotype, in which the double subscript denotes the crossbred parents and the triple represents the progeny produced by appropriate mating.

RESULTS AND DISCUSSION

Overall mean body weights of 428 calves were 26.2, 123.9, 178.7 and 225.0 kg at birth, 6, 12 and 18 months of age, respectively.

TABLE 1. MEAN SQUARES FROM ANALYSES OF VARIANCE FOR BODY WEIGHTS

Source	df	Body weights (kg) at			
		Birth	6 mth	12 mth	18 mth
Mating type	8	175**	6,952**	12,904**	24,599**
Sex of dam	1	625**	12,876**	28,443**	69,583**
Parity of dam	6	16	539	167	1,310
Age of dam	6	22	996*	264	981
Year of birth	6	32	4,478**	4,976**	5,723**
Remainder	400	14	388	688	1,189

* $P < .05$

** $P < .01$

Mean squares from analyses of variance for the body weights are shown in table 1. Mating type and sex of calf were significant sources of variation

TABLE 2. LEAST SQUARES MATING GROUP MEANS AND STANDARD ERRORS FOR BODY WEIGHTS

Mating type[a]	Number	Body weights (kg) at Birth	6 mth	12 mth	18 mth
Overall mean	428	26.2 ± 0.29	123.9 ± 1.56	178.7 ± 2.07	225.0 ± 2.72
Straightbred					
K	59	23.0 ± 0.55	101.8 ± 2.92	143.5 ± 3.89	179.3 ± 5.11
B	60	26.7 ± 0.54	137.6 ± 2.86	196.9 ± 3.81	253.3 ± 5.01
S	40	29.8 ± 0.63	128.7 ± 3.36	188.8 ± 4.47	234.9 ± 5.88
Average		26.5	122.7	176.4	222.5
F_1					
BK	42	26.4 ± 0.65	115.7 ± 3.43	169.6 ± 4.56	220.2 ± 6.00
SK	21	25.3 ± 0.90	105.3 ± 4.76	167.9 ± 6.34	197.3 ± 8.33
Average		25.9	110.5	168.8	208.8
Backcross					
BBK	44	25.7 ± 0.69	133.2 ± 3.67	193.4 ± 4.89	238.8 ± 6.43
SSK	44	27.7 ± 0.75	133.3 ± 3.99	183.4 ± 5.31	230.2 ± 6.98
Average		26.7	133.3	188.4	234.5
Composite					
BK x BBK	58	24.2 ± 0.55	126.3 ± 2.89	182.4 ± 3.85	241.7 ± 5.06
SK x SSK	60	27.0 ± 0.56	133.1 ± 2.95	182.5 ± 3.93	229.2 ± 5.17
Average		25.6	129.7	182.5	235.5

a. Mating type coded as : K = Cheju Native Cattle, B = Brahman, S = Santa Gertrudis and breed of sire appears first, i.e., BK x BBK represents a crossbred calf produced by a crossbred bull (BK) and a grade cow (BBK) which was produced by back crossing a Brahman bull to Brahman x Cheju native cow.

for the body weight and yearling weight while the sex effect was significant.

Least squares means for cattle had lighter birth weight and yearling age. Unweighted means for the calves of the heterozygosity of the Cheju native cattle and greater proportion of (6.1%) on birth weight

TABLE 3. ESTIMATES OF CROSS

Body weight at

birth
6 mth
12 mth
18 mth

TABLE 4 ESTIMA BODY W

Body weights at

$ x BK
birth
6 mth
12 mth
18 mth

$ x SK
birth
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for the body weights of all periods. Age of dam was significant on the weaning weight and year of birth on the weights at weaning, yearling and 18 months of age while the parity which is highly confounded with age of dam was not significant.

Least squares mating group means are presented in table 2. Cheju native cattle had lighter weights than any other straightbreds or crossbreds at any age. Unweighted mating type averages showed that F_1 calves were smaller than the calves of straightbreds, backcrosses or composite lines. Though maximum heterozygosity can be attained in the F_1 calves, the additive contribution of Cheju native cattle to F_1 calves influenced their growth with a relatively greater proportion (table 3). Brahman crosses expressed largest heterosis (6.1%) on birth weight while Santa Gertrudis crosses showed negative values of

TABLE 3. ESTIMATED ADDITIVE AND NON-ADDITIVE EFFECTS FOR BODY WEIGHTS IN F_1 CROSSBREDS

Body weight at	BK				SK			
	Additive		Non-additive		Additive		Non-additive	
	kg	%	kg	%	kg	%	kg	%
birth	24.8	93.9	1.6	6.1	26.3	104.4	-1.1	-4.4
6 mth	119.7	103.5	-4.0	-3.5	115.2	109.4	-9.9	-9.4
12 mth	170.1	100.4	-0.6	-0.4	166.1	98.9	1.8	1.1
18 mth	216.4	98.4	3.9	1.8	207.2	105.2	-9.8	-5.2

non-additive effects on the weights at birth, weaning and 18 months of age. Purebred Brahman grew faster than other breeds or crosses showing better adaptability to the specific environmental conditions provided by this subtropical island. The weight at 18 months of age of BK crosses expressed heterotic effect of 1.8% while SK showed a negative heterosis.

TABLE 4 ESTIMATED ADDITIVE AND NON-ADDITIVE EFFECTS AND MATERNAL HETEROSIS ON BODY WEIGHTS IN BACKCROSSES (B x BK AND S x SK)

Body weights at	Additive		Non-additive		Maternal		Total heterosis	
	kg	%	kg	%	kg	%	kg	%
B x BK								
birth	25.69	100.1	0.81	3.2	-0.83	-3.3	-0.02	-0.1
6 mth	128.64	96.6	-2.02	-1.5	6.60	4.9	4.58	3.4
12 mth	183.49	94.9	-0.30	-0.2	10.20	5.3	9.90	5.1
18 mth	234.89	98.3	-1.93	0.8	2.04	0.9	3.97	1.7
S x SK								
birth	28.01	100.3	-0.55	-2.0	0.18	0.7	-0.37	-1.3
6 mth	121.92	91.5	-4.99	-3.8	16.38	12.3	11.39	8.5
12 mth	177.44	96.8	0.90	0.5	5.06	3.7	5.96	4.2
18 mth	221.07	96.0	-4.92	-2.1	11.23	6.1	6.31	4.0

Estimated additive and non-additive effects and maternal heterosis on weights in the backcrosses are in table 4. Maternal heterosis attained in

Brahman backcrosses were 4.9%, 5.3% and 0.9% on the weights at weaning, yearling and 18 months of age, respectively gaining total heterosis of 3.4%, 5.1% and 1.7%. In Santa Gertrudis crosses, the maternal heterosis was highest for the weaning weight followed by that for the weight at 18 months of age. Though negative non-additive effects were shown on most of the traits studied, positive values of total heterosis were gained that were attributed to greater maternal effects on the weights at weaning and postweaning. Maternal heterosis for postweaning traits was hardly explainable, but necessitated further research on this herd with harsh environment.

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